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Occupation and breast cancer in women 20–44 years of age (United States)

Susan L. Teitelbaum[1,*], Julie A. Britton[1], Marilie D. Gammon[2], Janet B. Schoenberg[3], Donna J. Brogan[4], Ralph J. Coates[5], Janet R. Daling[6], Kathleen E. Malone[6], Christine A. Swanson[7] & Louise A. Brinton[8]
[1]*Division of Environmental Health Science, Department of Community and Preventive Medicine, Mount Sinai School of Medicine, New York, NY, USA;* [2]*Department of Epidemiology, School of Public Health, University of North Carolina, Chapel Hill, NC, USA;* [3]*Cancer Epidemiology Services at the New Jersey Department of Health and Senior Services, Trenton, NJ, USA;* [4]*Department of Biostatistics, Rollins School of Public Health, Emory University, Atlanta, GA, USA;* [5]*Division of Cancer Prevention and Control, Centers for Disease Control, Atlanta, GA, USA;* [6]*Fred Hutchinson Cancer Research Center/University of Washington, Seattle, WA, USA;* [7]*Office of Dietary Supplements, National Institutes of Health, Bethesda, MD, USA;* [8]*Division of Cancer Epidemiology and Genetics, National Cancer Institute, Bethesda, MD, USA*

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Abstract

Objective: To examine the relation between breast cancer risk and job history among women 20–44 years of age who participated in a multi-center, population-based, case–control study.
Methods: Participants consisted of women newly diagnosed with breast cancer (1642) and controls identified by random-digit dialing (1494). Details about the three longest jobs were collected and coded by an industrial hygienist. Odds ratios and 95% confidence intervals were calculated and adjusted for age, study site, and other breast cancer risk factors.
Results: Several occupational and industrial categories were found to influence breast cancer risk. Stratification of the study population by parity revealed differences in breast cancer risk between the two groups for several occupational categories, including *teachers*, *librarians or counselors* (increased risk only among parous women) and *natural scientists and mathematicians* (decreased risk only among nulliparous women).
Conclusions: This is among the first population-based case–control studies to examine occupational history and breast cancer risk in young women, with the ability to consider a wide array of potential confounders, including reproductive characteristics. This study provides further evidence of an increased breast cancer risk for several occupations and industries. Other findings were not as strongly supported by previous investigations.

Introduction

Migration studies suggest that a woman's environmental exposures may influence her risk of breast cancer [1]. Such exposures may include those received while at work. In 2001, women comprised 47% of the employed US workforce, and almost three quarters of women between the ages of 20 and 45 were employed [2], making it important to consider occupational exposures as potential breast cancer risk factors.

Occupational exposures have been studied less thoroughly than other potential risk factors for breast cancer, so examination of occupation in relation to breast cancer risk provides an opportunity to identify potential sources of exposures not regularly considered or investigated. The workplace can expose women to chemical, biological, or physical agents that could influence breast cancer risk. Women who work in manufacturing, chemical and pharmaceutical industries may be exposed to chemical solvents [3]. Health care professionals, including physicians and nurses, may be exposed to chemotherapeutic agents, various chemicals,

* Address correspondence to: Susan L. Teitelbaum, PhD, Department of Community and Preventive Medicine, Mount Sinai School of Medicine, One Gustave L. Levy Place, Box 1043, New York, NY 10029, USA. E-mail: susan.teitelbaum@mssm.edu

and ionizing radiation [4]. Electromagnetic field (EMF) exposure has been examined as a possible risk factor, and women with occupations in the electrical and electronics industries as well as occupations requiring extensive use of computers may be exposed to EMF [5]. Further, jobs that require higher levels of physical activity have been proposed to decrease breast cancer risk [6, 7].

Currently, there is no strong evidence that any particular occupation influences breast cancer risk [8]. Occupations that have been adversely linked to breast cancer risk include teachers, chemists, health care workers, as well as professional and technical occupations, although the evidence is inconsistent [3]. The elevated risk among women employed in these occupations has often been attributed to reproductive characteristics such as delayed childbirth, reduced number of children or little or no breastfeeding. However, several of these professions (*e.g.*, chemists and health care professionals), as well as others (*e.g.*, cosmetologists), may involve exposure to chemicals that are potential breast carcinogens [4]. Relatively few comprehensive studies of job history and breast cancer have been conducted. Using detailed information on the three longest held occupations and their corresponding industries, which can indicate potential occupational exposures, this relation was examined among young women who participated in a multi-center, population-based, breast cancer case–control study.

Materials and methods

The methods of this study have been described previously [9]. The main objectives of the Women's Interview Study of Health were to investigate the relation of breast cancer in women under the age of 45 with oral contraceptive use, alcohol consumption, diet, and other characteristics. In brief, study participants were identified in three geographic regions (Atlanta, GA; Seattle, WA; and central NJ) between May 1, 1990 and December 31, 1992. Cases were 20–44 newly diagnosed with breast cancer. Controls, identified through random-digit dialing (RDD) [10], were women who had never been diagnosed with breast cancer, frequency matched to the anticipated age distribution of cases by five-year age group and study site.

Structured in-person interviews were completed by 1642 cases (84.4%) and 1496 controls (78.2%). The overall control response rate (product of RDD screener and interview response rates) was 70.8%. Subject refusal was the main reason women did not complete the interview (6.6% for cases and 12.9% for controls); physician refusal accounted for 5.8% of case non-participation. This study was approved by the institutional review board at each of the participating institutions and signed informed consent was obtained from all study participants. The interview included questions on demographic factors, reproductive and menstrual history, contraceptive behavior, use of exogenous hormones, medical history, body size and physical activity, diet, alcohol consumption, smoking, and family history of cancer. The relation between many of these factors and breast cancer risk has already been examined. Oral contraceptive users and alcohol drinkers as well as women who had a late age at first birth, an early age at menarche, an induced abortion, a previous breast biopsy, a first degree relative with breast cancer, or a low BMI were found to be at increased breast cancer risk [9, 11–16]. However, waist to hip ratio, cigarette smoking, miscarriages, electric blanket use, and recreational exercise were not found to be positively associated with breast cancer risk [9, 12, 17–19].

During the interview, an occupational history of the three jobs held for the longest time was obtained; all reported jobs had to have been held for six months or longer. Details collected on each job included the position title, usual activities or duties performed, what the company made or did, the start year, and the total number of years of employment. Using this information, a trained industrial hygienist assigned industry and occupation codes according to the 1987 Standard Industrial Code (SIC) [20] and 1980 Standard Occupational Code (SOC) [21]. The detailed SIC and SOC codes were then grouped according to their overriding classifications. Twenty-four women reported that they were never employed for at least six months and none of the participants reported having been a housewife as any of their three longest held jobs. Two control women refused to provide information about their occupational history leaving 1494 controls and 1642 cases for inclusion in the analyses.

Duration of work in a particular occupation or industry was categorized as never, less than five years, or five + years. Latency, the number of years that elapsed between starting work in an occupation or industry and the reference date (the date of diagnosis for cases, and the date of RDD telephone screening for controls) was categorized as never, less than 10 years, or 10 + years.

Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using unconditional logistic regression [22]. To estimate the associated breast cancer risk for each occupation, we considered women who had never held that job as unexposed. Similarly, to estimate the risk associated with working in a particular industry, we considered women who had never worked in that

industry as unexposed. All logistic regression models were adjusted for the frequency matching variables (age and geographic site). The following covariates were considered as potential confounders: menopausal status; age at menarche; age at first birth; number of live births; ever breast fed; level of education; marital status; race; body mass index (BMI, weight in kilograms/height in meters squared); ever use of oral contraceptives; smoking history; usual alcohol use; average lifetime weekly recreational physical activity; history of breast biopsy; and family history of breast cancer. Of these factors, age at first birth, number of live births, and level of education were retained since their inclusion resulted in the most parsimoniously adjusted model relative to the age- and geographic site adjusted models. To avoid unstable and uninformative estimates of association, ORs were only calculated for an individual job or industry category if at least 10 cases and 10 controls reported working in the category. Tests for trend in duration and latency were conducted if successive levels were increasing or decreasing. Presence of a trend was determined by examining the statistical significance of a categorical variable with the values of 0,1,2 indicating the level of duration (never, <5 years, 5+ years) or latency (never, <10 years, 10+ years).

Results

The number of jobs reported by each woman ($\chi^2 = 3.2$, $p = 0.4$) and employment duration (14.1 *versus* 13.6 years, $p = 0.05$) did not differ by case–control status. However, parous case women started working before having their first child more often than parous controls (75.7 *versus* 70.2%, $\chi^2 = 9.3$, $p < 0.01$). Similar proportions of cases and controls reported having held only one job (19.7 and 21.6%) while less than one percent of each group reported never having been employed for at least six months. The most frequently held occupations among cases and controls, respectively were: *service* (24.8 and 29.2%); *marketing and sales* (23.6 and 22.3%); *executive, administrative and managerial* (20.5 and 20.1%); *teachers, librarians and counselors* (17.6 and 14.5%); and *secretaries, stenographers and typists* (17.3 and 15.4%). Industries commonly worked in by cases and controls, respectively were: *finance, insurance and real estate* (21.6 and 20.0%); *services industry: educational services* (21.2 and 20.1%); *services industry: health services* (20.0 and 22.0%); and *retail industry: eating and drinking places* (11.3 and 12.8%).

The estimates of association for the majority of occupations examined were not substantially different from one (Table 1). Two occupational categories, *handlers, equipment cleaners, helpers and laborers* and *computer and peripheral equipment operators*, were suggestive of an increased risk with ORs greater than 1.5; however as evidenced by the wide CI, the estimates were unstable. The occupation group, *teacher, librarian or counselor* had a weaker, but positive association with borderline significance (OR = 1.3, 95% CI: 1.0, 1.6). Several occupations were suggestive of decreased risk with unstable estimates of effect of less than or equal to 0.7. Among these occupations with the strongest inverse association, only the estimate for *writers, artists, entertainers or athletes* approached statistical significance (OR = 0.7, 95% CI: 0.5, 1.0).

For women who were or *adjusters, investigators or collectors* increased breast cancer risk was only associated with having worked in this occupation for less than five years or having started 10 or more years prior to reference date. *Teachers, librarians or counselors* who worked for shorter, but not longer, periods of employment were at significantly increased risk (OR = 1.6, 95% CI: 1.2, 2.2); breast cancer risk did differ when examined by latency. Both *production work* and *material recording, scheduling, and distributing clerks* were suggestive of an increased breast cancer risk for women employed in these occupations for longer, but not shorter durations. Employment in the latter category was also suggestive of an increased risk if work started 10 or more years prior to reference date. A similar latency pattern was observed for the *social scientist, social worker, religious worker, or lawyer* category. The suggested decreased breast cancer risk for *writers, artists, entertainers and athletes* became more pronounced for women who only held these jobs less than five years (OR = 0.4, 95% CI: 0.2, 0.8). A difference in breast cancer risk according to latency was observed for *health technologists and technicians* with increased risk associated with starting work closer to but not farther from reference date.

Stratification of the study population by parity revealed differences in breast cancer risk between the two groups for several occupational categories (Table 2). Nulliparous women who were *natural scientists and mathematicians* were at decreased risk (OR = 0.4, 95% CI: 0.2, 0.9) while parous women employed in this category were not. Increased risk was suggested among nulliparous, but not parous, women who worked in the occupational categories: *social scientists, social workers, religious workers and lawyers*; *record clerks*; and *miscellaneous administrative support*. Parous, but not nulliparous, women who were *teachers, librarians and counselors* or *adjusters, investigators and collectors* were at increased risk of breast cancer (OR = 1.3, 95% CI: 1.0, 1.7 and OR = 1.5, 95% CI: 0.9, 2.5, respectively).

Table 1. Adjusted ORs and 95% CIs for breast cancer in relation to ever having worked in a specific occupation among women under age 45 in Atlanta, New Jersey and Seattle, 1990–1992

Occupation[a]	Ever held job ≥6 months								Duration				Latency (years started job before reference date)			
									<5 years		5+ years		<10 years		10+ years	
	Ca	Co	OR[b]	95% CI	OR[c]	95% CI	OR[d]	95% CI	OR[c]	95% CI	OR[c]	95% CI	OR[c]	95% CI	OR[d]	95% CI
Executive, administrative and managerial	342	302	**1.0**	0.9 1.2	**1.0**	0.8 1.2	**0.9**	0.8 1.1	**1.0**	0.7 1.3	**1.0**	0.8 1.2	**1.1**	0.9 1.5	**0.9**	0.7 1.1
Natural scientists and mathematicians	43	46	**0.8**	0.5 1.3	**0.7**	0.5 1.1	**0.7**	0.4 1.0	–	– –	–	– –	**0.6**	0.3 1.2	**0.8**	0.5 1.4
Social scientists, social workers, religious workers and lawyers	92	63	**1.4**	1.0 1.9	**1.3**	0.9 1.8	**1.2**	0.9 1.8	**1.2**	0.7 2.1	**1.3**	0.9 2.0	**1.0**	0.6 1.8	**1.5**	0.9 2.3
Teachers, librarians and counselors	294	218	**1.2**	1.0 1.5	**1.2**	1.0 1.6	**1.3**	1.0 1.6	**1.6**	1.2 2.2	**1.1**	0.8 1.4	**1.2**	0.8 1.7	**1.3**	1.0 1.6
Registered nurses, pharmacists, dieticians, therapists and physician's assistants	107	90	**1.1**	0.8 1.4	**1.1**	0.8 1.4	**1.1**	0.8 1.5	**1.1**	0.6 2.1	**1.0**	0.7 1.4	**0.9**	0.5 1.7	**1.1**	0.8 1.5
Writers, artists, entertainers and athletes	76	86	**0.8**	0.6 1.1	**0.7**	0.5 1.0	**0.7**	0.5 1.0	**0.4**	0.2 0.8	**0.9**	0.6 1.4	**0.6**	0.4 1.1	**0.8**	0.5 1.1
Health technologists and technicians	62	69	**0.8**	0.6 1.2	**0.8**	0.6 1.2	**0.9**	0.6 1.3	**1.0**	0.5 1.9	**0.8**	0.5 1.2	**1.5**	0.8 3.1	**0.7**	0.5 1.0
Technologists and technicians, except health	81	82	**0.9**	0.7 1.2	**0.9**	0.6 1.2	**0.9**	0.6 1.2	**0.9**	0.6 1.3	**0.8**	0.5 1.3	**0.7**	0.5 1.2	**0.9**	0.6 1.4
marketing and sales	394	336	**1.1**	0.9 1.3	**1.1**	0.9 1.3	**1.1**	0.9 1.3	**1.2**	1.0 1.5	**1.0**	0.8 1.3	**1.1**	0.8 1.4	**1.1**	0.9 1.4
Administrative support occupations, including clerical																
Supervisors	96	102	**0.8**	0.6 1.1	**0.8**	0.6 1.1	**0.8**	0.6 1.1	**0.6**	0.4 1.0	**1.0**	0.7 1.4	**0.6**	0.4 1.0	**1.0**	0.7 1.4
Computer and peripheral equipment operators	22	11	**1.8**	0.9 3.7	**1.9**	0.9 3.9	**1.8**	0.8 3.8	–	– –	–	– –			–	– –
Secretaries, stenographers and typists	289	232	**1.1**	0.9 1.4	**1.1**	0.9 1.4	**1.1**	0.9 1.4	**1.2**	0.9 1.6	**1.1**	0.9 1.4	**1.0**	0.6 1.5	**1.2**	1.0 1.4
General office	140	137	**0.9**	0.7 1.2	**0.9**	0.7 1.2	**0.9**	0.7 1.2	**0.9**	0.6 1.2	**1.0**	0.7 1.4	**1.1**	0.7 1.7	**0.9**	0.7 1.2
Information clerks	72	81	**0.8**	0.6 1.1	**0.8**	0.6 1.1	**0.7**	0.5 1.1	**0.8**	0.5 1.2	**0.8**	0.5 1.4	**0.5**	0.3 1.0	**0.9**	0.6 1.4
Correspondence clerks and order clerks	28	24	**1.0**	0.6 1.8	**1.0**	0.6 1.8	**1.0**	0.6 1.7	**1.1**	0.5 2.2	**0.9**	0.4 2.2	–	– –	–	– –
Record clerks	69	52	**1.2**	0.8 1.7	**1.2**	0.8 1.7	**1.2**	0.8 1.8	**1.2**	0.8 1.8	**1.2**	0.6 2.5	**1.3**	0.6 2.4	**1.1**	0.7 1.8
Financial record processing	135	147	**0.8**	0.6 1.1	**0.8**	0.6 1.1	**0.8**	0.6 1.1	**0.8**	0.6 1.1	**0.8**	0.6 1.2	**1.0**	0.6 1.6	**0.8**	0.6 1.0
Communications equipment operators	27	18	**1.4**	0.7 2.5	**1.4**	0.7 2.5	**1.3**	0.7 2.5	–	– –	–	– –	–	– –	–	– –
Mail and message distributing	13	10	**1.1**	0.5 2.6	**1.1**	0.5 2.6	**1.3**	0.6 3.2	–	– –	–	– –	–	– –	–	– –
Material, recording, scheduling, and distributing clerks	53	51	**1.0**	0.7 1.4	**1.0**	0.7 1.4	**1.0**	0.7 1.5	**0.8**	0.5 1.3	**1.3**	0.7 2.5	**0.7**	0.4 1.3	**1.2**	0.7 2.1
Adjusters, investigators and collectors	62	41	**1.4**	0.9 2.1	**1.4**	0.9 2.0	**1.5**	1.0 2.3	**1.7**	1.0 3.0	**1.0**	0.6 1.8	**1.0**	0.5 2.1	**1.6**	0.9 2.6
Miscellaneous administrative support, including clerical	149	121	**1.1**	0.9 1.5	**1.2**	0.9 1.5	**1.1**	0.8 1.4	**1.2**	0.9 1.8	**1.1**	0.8 1.6	**1.2**	0.8 1.8	**1.2**	0.9 1.6
Service	413	439	**0.8**	0.7 1.0	**0.9**	0.8 1.1	**0.9**	0.8 1.1	**1.0**	0.8 1.3	**0.8**	0.6 1.0	**0.9**	0.6 1.2	**0.9**	0.8 1.1
Agriculture, forestry and fishing	18	25	**0.7**	0.4 1.3	**0.7**	0.4 1.3	**0.8**	0.4 1.5	–	– –	–	– –	–	– –	–	– –
Mechanics and repairers	14	11	**1.1**	0.5 2.5	**1.2**	0.5 2.6	**1.2**	0.5 2.7	–	– –	–	– –	–	– –	–	– –
Precision production	39	47	**0.7**	0.5 1.2	**0.8**	0.5 1.2	**0.8**	0.5 1.3	**0.6**	0.4 1.1	**1.1**	0.5 2.1	**0.7**	0.3 1.6	**0.8**	0.5 1.4
Production working	94	97	**0.9**	0.6 1.2	**0.9**	0.7 1.3	**1.0**	0.7 1.4	**0.7**	0.5 1.1	**1.3**	0.8 2.1	**0.8**	0.4 1.5	**1.0**	0.7 1.4
Transportation and material moving	27	25	**1.0**	0.6 1.7	**1.1**	0.6 1.9	**1.2**	0.6 2.1	–	– –	–	– –	**1.0**	0.4 2.1	**1.3**	0.6 2.7
Handlers, equipment cleaners, helpers and laborers	34	22	**1.4**	0.8 2.4	**1.6**	0.9 2.7	**1.6**	0.9 2.8	–	– –	–	– –	–	– –	–	– –
No jobs held for at least 6 months	14	10	**1.1**	0.5 2.4	**1.4**	0.6 3.0	**1.6**	0.7 3.8	–	– –	–	– –	–	– –	–	– –

[a] Reference group for each occupation is composed of women who never held that specific occupation; ORs were only calculated if at least 10 cases and 10 controls reported working in the category within each stratum.

[b] Adjusted for age and geographic site.

[c] Adjusted for age; geographic site; age at first birth; number of live births; and level of education.

[d] Adjusted for age; geographic site; menopausal status; age at menarche; age at first birth; number of live births; ever breast fed; level of education; marital status; race; BMI (weight in kilograms/height in meters squared); ever use of.

Table 2. Adjusted ORs and 95% CIs for breast cancer in relation to ever having worked in a specific occupation according to parity among women under age 45 in Atlanta, New Jersey and Seattle, 1990–1992

Occupation[a]	Nulliparous only				Parous only			
	Ca	Co	**OR**[b]	95% CI	Ca	Co	**OR**[c]	95% CI
Executive, administrative and managerial	122	101	**1.0**	0.7 1.4	219	201	**1.0**	0.8 1.2
Natural scientists and mathematicians	13	23	**0.4**	0.2 0.9	30	23	**1.0**	0.6 1.8
Social scientists, social workers, religious workers and lawyers	33	17	**1.7**	0.9 3.1	59	46	**1.1**	0.8 1.7
Teachers, librarians and counselors	66	54	**1.0**	0.6 1.5	228	164	**1.3**	1.0 1.7
Registered nurses, pharmacists, dieticians, therapists and physician's assistants	29	22	**1.1**	0.6 2.0	78	68	**1.0**	0.7 1.4
Writers, artists, entertainers and athletes	26	32	**0.7**	0.4 1.1	50	54	**0.7**	0.5 1.1
Health technologists and technicians	16	12	**1.1**	0.5 2.4	46	57	**0.8**	0.5 1.1
Technologists and technicians, except health	29	25	**0.9**	0.5 1.6	52	57	**0.8**	0.5 1.2
Marketing and sales	101	77	**1.2**	0.8 1.6	293	259	**1.1**	0.9 1.3
Administrative support occupations, including clerical								
Supervisors	30	24	**1.1**	0.6 1.9	66	78	**0.8**	0.5 1.1
Secretaries, stenographers and typists	65	51	**1.0**	0.7 1.5	224	181	**1.2**	0.9 1.5
General office	32	27	**0.9**	0.5 1.6	107	110	**0.9**	0.7 1.2
Information clerks	18	16	**1.0**	0.5 2.0	54	65	**0.8**	0.5 1.1
Record clerks	18	11	**1.4**	0.6 3.1	51	41	**1.1**	0.8 1.8
Financial record processing	34	32	**0.9**	0.5 1.5	101	115	**0.8**	0.6 1.1
Material, recording, scheduling, and distributing clerks	10	10	**0.8**	0.3 2.1	43	41	**1.0**	0.7 1.6
Adjusters, investigators and collectors	18	14	**1.0**	0.5 2.1	44	27	**1.5**	0.9 2.5
Miscellaneous administrative support, including clerical	35	20	**1.5**	0.8 2.6	114	101	**1.1**	0.8 1.5
Service	87	71	**1.1**	0.7 1.6	326	368	**0.9**	0.7 1.0
Precision production	2	6	–	– –	37	41	**0.9**	0.6 1.4
Production working	14	13	**0.8**	0.4 1.7	80	84	**1.0**	0.7 1.4

[a] Reference group for each occupation is composed of women who never held that specific occupation; ORs were only calculated if at least 10 cases and 10 controls reported working in the category within each stratum.

[b] Adjusted for age; geographic site; and level of education.

[c] Adjusted for age; geographic site; age at first birth; number of live births; and level of education.

For ever having worked in a specific industry, 40 of the 49 categories (82%) had risk estimates from 0.7 to 1.4 (Table 3). Of those with an increased risk (*amusement and recreation services*; *miscellaneous manufacturing industries*; *general merchandise stores*; *justice*, *public order and safety*; *national security and international affairs*; and *electric*, *gas and sanitary services*) all categories except *miscellaneous manufacturing industries* had significant or borderline significant breast cancer risk estimates. An OR less than 0.7 was observed for women who ever worked in the following industries: *local and interurban passenger transit* (OR = 0.5, 95% CI: 0.3, 1.1); *private households* (OR = 0.6, 95% CI: 0.4, 0.9); and *rubber and miscellaneous plastic products* (OR = 0.6, 95% CI: 0.3, 1.4).

Several industries were associated with increased breast cancer risk when examined by duration and latency. The increased risk seen for having ever worked in *general merchandise stores* was more pronounced in those who did this work for less than five years (OR = 1.7, 95% CI: 1.2, 2.5) than in those who did this work for five or more years (OR = 1.3, 95% CI: 0.9, 2.0). Longer latency for working in this retail industry was associated with an increased risk of breast cancer. Having worked in the *amusement and recreation services* followed a similar pattern of association with respect to duration and latency.

Discussion

In this investigation of job history and breast cancer risk among young women, several occupational and industrial categories were identified as influencing risk. The available detailed job history allowed us to investigate breast cancer risk associated with employment duration and latency, while information on reproductive history allowed us to examine job-related risk among parous and nulliparous women. Occupations that influence breast cancer risk have been identified through epidemiologic studies of different designs using either breast cancer mortality or incidence as the outcome. We restrict our discussion to investigations of incident breast cancer, because the results of mortality studies may not be directly comparable to our results. Furthermore, mortality may be influenced by etiologic determinants as well as factors that influence survival, and mortality studies generally lack the information needed to control for the effects of potential confounding (which make interpretation of those studies' results even more difficult and less comparable).

The relationship between occupation and breast cancer has been thoroughly reviewed [3, 23]. Many of the occupations and industries for which we observed some associations with breast cancer risk have been reported on in other studies, but because of different coding methodology used among studies, occupational groups are not always identically defined. Our *adjusters, investigators and collectors* category includes a wide range of occupations, for example insurance adjusters, bill and account collectors, and customer complaint clerks [21]. Similar to our findings, one population-based registry study found a significant excess incidence of breast cancer among insurance raters and claims adjusters [24], whereas in other case–control studies no increased risk was observed for accounting/auditing clerks [25] or for insurance, bank and other finance clerks [26]. No association between working in general merchandise stores and breast cancer risk was found in a large Canadian case–control study [26], which is in contrast to our finding of increased risk. Our observation of decreased breast cancer risk associated with the occupational category of *writers*, *artists*, *entertainers and athletes* was consistent with the findings of two large studies, one conducted in the Nordic countries and the other in Canada [26, 27] but in opposition to others [24, 25, 28]. Our finding of a small increased risk for religious workers, especially among those who started in this occupation 10 or more years before reference date is supported by findings in the Nordic countries [24, 27], but not in the US [29]. The observed increased risk found among Nordic technical/chemical/physical/biological workers [27] was in contrast to our finding of decreased risk for technicians. As reported here and in two other studies, ever having been a *natural scientist or mathematician* was suggestive of decreased or no risk [25, 26].

Our finding of decreased breast cancer risk for women who had agricultural occupations is well supported in the literature [23]. One study provided some support for our finding of decreased breast cancer risk for women who worked in *private households* [26], while another did not [25]. Occupational physical activity has been proposed to lower breast cancer risk [6] which may be an underlying factor for the decreased risk observed for working in private households and agricultural jobs [7]. It is difficult to speculate on the biological plausibility of many of the other relationships because the specific exposures linking the occupation to breast cancer risk are not known. Also, it is possible that these are spurious findings given the large number of comparisons made in many occupational analyses.

As in our study, several epidemiologic studies have identified teachers [24–26, 28, 30–32] and librarians [24, 26, 29, 31] as occupational groups at higher risk of breast cancer, yet in other investigations, teachers were

Table 3. Adjusted ORs and 95% CIs for breast cancer in relation to ever having worked in a specific industry among women under age 45 in Atlanta, New Jersey and Seattle, 1990–1992

Industry[a]	Ever held job ≥6 months					Duration									Latency (years started job before reference date)									
						<5 years					5+ years					<10 years					10+ years				
	Ca	Co	OR[b]	95%	CI	Ca	Co	OR[b]	95%	CI	Ca	Co	OR[b]	95%	CI	Ca	Co	OR[b]	95%	CI	Ca	Co	OR[b]	95%	CI
Agriculture, forestry and fishing	24	33	**0.7**	0.4	1.2	13	16	**0.8**	0.4	1.6	11	17	**0.6**	0.3	1.3	17	11	–	–	–	7	22	–	–	–
Construction	43	38	**1.1**	0.7	1.7	21	15	**1.4**	0.7	2.7	22	23	**0.9**	0.5	1.6	18	15	**1.2**	0.6	2.5	25	23	**1.0**	0.5	1.7
Manufacturing																									
Food and kindred products	34	28	**1.1**	0.7	1.9	21	12	**1.7**	0.8	3.5	13	16	**0.7**	0.3	1.5	7	11	–	–	–	27	17	–	–	–
Textile mill products	11	13	**0.7**	0.3	1.7	5	7	–	–	–	6	6	–	–	–	0	2	–	–	–	11	11	–	–	–
Apparel and other textile products	28	23	**1.2**	0.7	2.1	14	14	–	–	–	14	9	–	–	–	11	4	–	–	–	17	19	–	–	–
Printing and publishing	49	45	**0.9**	0.6	1.4	24	25	**0.9**	0.5	1.5	25	20	**1.0**	0.6	1.9	16	14	**1.0**	0.5	2.0	33	31	**0.9**	0.6	1.5
Chemicals and allied products	44	50	**0.7**	0.5	1.1	16	22	**0.7**	0.4	1.3	28	28	**0.8**	0.5	1.4	11	8	–	–	–	33	42	–	–	–
Rubber and miscellaneous plastics products	11	16	**0.6**	0.3	1.4	7	9	–	–	–	4	7	–	–	–	3	3	–	–	–	8	13	–	–	–
Fabricated metal products	15	19	**0.7**	0.4	1.4	11	9	–	–	–	4	10	–	–	–	4	6	–	–	–	11	13	–	–	–
Industrial machinery and equipment	35	36	**0.8**	0.5	1.3	17	24	**0.6**	0.3	1.2	18	12	**1.2**	0.6	2.4	11	7	–	–	–	24	29	–	–	–
Electronic and other electric equipment	40	50	**0.7**	0.5	1.1	21	25	**0.8**	0.4	1.4	19	25	**0.7**	0.4	1.2	10	10	**1.0**	0.4	2.3	30	40	**0.6**	0.4	1.1
Transportation equipment	47	49	**0.9**	0.6	1.4	23	23	**1.0**	0.5	1.7	24	26	**0.8**	0.5	1.5	10	15	**0.7**	0.3	1.5	37	34	**1.0**	0.6	1.6
Instruments and related products	30	30	**0.9**	0.5	1.5	11	10	**1.1**	0.5	2.6	19	20	**0.8**	0.4	1.5	8	14	–	–	–	22	16	–	–	–
Miscellaneous manufacturing industries	18	12	**1.5**	0.7	3.2	9	10	–	–	–	9	2	–	–	–	8	6	–	–	–	10	6	–	–	–
Transportation and public utilities																									
Local and interurban passenger transit	13	24	**0.5**	0.3	1.1	5	9	–	–	–	8	15	–	–	–	8	8	–	–	–	5	16	–	–	–
Trucking and warehousing	17	12	**1.4**	0.7	2.9	12	7	–	–	–	5	5	–	–	–	5	8	–	–	–	12	4	–	–	–
Transportation by air	35	35	**0.8**	0.5	1.4	10	16	**0.6**	0.3	1.3	25	19	**1.1**	0.6	2.0	4	5	–	–	–	31	30	–	–	–
Transportation services	23	25	**0.8**	0.4	1.4	10	10	**0.9**	0.4	2.1	13	15	**0.7**	0.3	1.5	12	9	–	–	–	11	16	–	–	–
Communications	105	88	**1.0**	0.8	1.4	33	28	**1.1**	0.7	1.8	72	60	**1.0**	0.7	1.4	26	23	**1.1**	0.6	2.0	79	65	**1.0**	0.7	1.4
Electric, Gas and sanitary services	25	12	**1.8**	0.9	3.6	8	7	–	–	–	17	5	–	–	–	3	5	–	–	–	22	7	–	–	–
Wholesale trade																									
Durable goods	50	55	**0.8**	0.6	1.3	23	24	**0.9**	0.5	1.7	27	31	**0.8**	0.5	1.3	18	24	**0.7**	0.4	1.4	32	31	**0.9**	0.6	1.5
Nondurable goods	48	43	**1.0**	0.6	1.5	25	19	**1.2**	0.6	2.1	23	24	**0.8**	0.5	1.5	17	12	**1.3**	0.6	2.8	31	31	**0.8**	0.5	1.4
Retail trade																									
General merchandise stores	139	86	**1.5**	1.2	2.0	86	47	**1.7**	1.2	2.5	53	39	**1.3**	0.9	2.0	27	20	**1.4**	0.8	2.6	112	66	**1.6**	1.1	2.2
Food stores	55	59	**0.9**	0.6	1.4	36	39	**1.0**	0.6	1.6	19	20	**0.9**	0.5	1.7	14	23	**0.7**	**0.3**	1.3	41	36	**1.1**	0.7	1.8
Automotive dealers and service stations	18	14	**1.2**	0.6	2.5	8	8	–	–	–	10	6	–	–	–	5	9	–	–	–	13	5	–	–	–

Table 3. (Continued)

Industry[a]	Ever held job ≥6 months					Duration									Latency (years started job before reference date)									
						<5 years					5+ years					<10 years					10+ years				
	Ca	Co	**OR**[b]	95%	CI	Ca	Co	**OR**[b]	95%	CI	Ca	Co	**OR**[b]	95%	CI	Ca	Co	**OR**[b]	95%	CI	Ca	Co	**OR**[b]	95%	CI
Apparel and accessory stores	57	55	**1.0**	0.7	1.4	34	35	**0.9**	0.6	1.5	23	20	**1.0**	0.6	1.9	13	11	**1.2**	0.5	2.7	44	44	**0.9**	0.6	1.4
Furniture and home furnishings stores	15	19	**0.7**	0.4	1.4	8	9	–	–	–	7	10	–	–	–	6	3	–	–	–	9	16	–	–	–
Eating and drinking places	189	193	**1.0**	0.8	1.2	118	108	**1.1**	0.8	1.5	71	85	**0.8**	0.6	1.1	39	52	**0.8**	0.5	1.2	150	141	**1.0**	0.8	1.3
Miscellaneous retail	89	82	**1.0**	0.7	1.4	54	55	**1.0**	0.6	1.4	35	27	**1.1**	0.7	1.9	37	26	**1.4**	0.8	2.3	52	56	**0.8**	0.6	1.2
Finance, insurance and real estate	361	301	**1.1**	0.9	1.3	149	119	**1.2**	0.9	1.5	212	182	**1.0**	0.8	1.3	91	96	**0.9**	0.7	1.3	270	205	**1.2**	1.0	1.4
Services																									
Hotels and other lodging places	30	39	**0.7**	0.4	1.2	17	19	**0.8**	0.4	1.6	13	20	**0.6**	0.3	1.2	9	13	–	–	–	21	26	–	–	–
Personal services	60	71	**0.8**	0.6	1.2	28	29	**0.9**	0.6	1.6	32	42	**0.7**	0.5	1.2	21	27	**0.8**	0.4	1.3	39	44	**0.9**	0.6	1.3
Business services	139	130	**0.9**	0.7	1.2	74	67	**1.0**	0.7	1.4	65	63	**0.9**	0.6	1.3	62	65	**0.9**	0.6	1.3	77	65	**1.0**	0.7	1.4
Amusement and recreation services	58	38	**1.5**	1.0	2.2	38	18	**2.1**	1.2	3.7	20	20	**0.9**	0.5	1.7	11	14	**0.8**	0.4	1.7	47	24	**1.8**	1.1	3.0
Health services	334	331	**0.9**	0.8	1.1	102	120	**0.8**	0.6	1.1	232	211	**1.0**	0.8	1.2	71	79	**0.9**	0.6	1.2	263	252	**0.9**	0.8	1.1
Legal services	58	43	**1.2**	0.8	1.8	17	18	**0.9**	0.4	1.7	41	25	**1.4**	0.9	2.4	14	16	**0.8**	0.4	1.8	44	27	**1.4**	0.9	2.3
Educational services	354	303	**1.0**	0.8	1.2	139	115	**1.1**	0.8	1.4	215	188	**1.0**	0.8	1.2	92	88	**1.0**	0.7	1.4	262	215	**1.0**	0.8	1.3
Social services	98	95	**1.0**	0.7	1.3	50	52	**0.9**	0.6	1.4	48	43	**1.0**	0.6	1.5	39	45	**0.9**	0.6	1.3	59	50	**1.0**	0.7	1.5
Membership organizations	37	35	**0.9**	0.6	1.5	16	15	**1.0**	0.5	1.9	21	20	**0.9**	0.5	1.8	18	19	**0.9**	0.5	1.7	19	16	**1.0**	0.5	2.0
Engineering and management services	97	75	**1.1**	0.8	1.5	42	40	**1.0**	0.6	1.5	55	35	**1.3**	0.9	2.0	33	34	**0.9**	0.5	1.4	64	41	**1.3**	0.9	2.0
Private households	31	54	**0.6**	0.4	0.9	24	31	–	–	–	7	23	–	–	–	16	30	**0.6**	0.3	1.0	15	24	**0.6**	0.3	1.2
Services, not elsewhere specified	23	20	**1.0**	0.5	1.8	4	13	–	–	–	19	7	–	–	–	8	11	–	–	–	15	9	–	–	–
Public administration																									
Executive, legislative and general	30	27	**0.9**	0.5	1.5	12	15	**0.6**	0.3	1.4	18	12	**1.2**	0.6	2.6	10	9	–	–	–	20	18	–	–	–
Justice, public order and safety	33	19	**1.6**	0.9	2.9	11	13	–	–	–	22	6	–	–	–	7	10	–	–	–	26	9	–	–	–
Administration of human resources	34	23	**1.3**	0.8	2.2	15	9	–	–	–	19	14	–	–	–	15	5	–	–	–	19	18	–	–	–
Environmental quality and housing	13	11	**1.0**	0.5	2.3	6	7	–	–	–	7	4	–	–	–	4	4	–	–	–	9	7	–	–	–
Administration of economic programs	13	12	**1.0**	0.5	2.3	8	9	–	–	–	5	3	–	–	–	3	5	–	–	–	10	7	–	–	–
National security and international affairs	39	23	**1.7**	1.0	2.9	30	8	–	–	–	9	15	–	–	–	10	6	–	–	–	29	17	–	–	–
Nonclassifiable establishments	37	27	**1.2**	0.7	2.0	13	12	**0.9**	0.4	2.0	24	15	**1.4**	0.8	2.8	10	4	–	–	–	27	23	–	–	–

[a] Reference group for each industry is composed of women who never worked in that specific industry; ORs were only calculated if at least 10 cases and 10 controls reported working in the category within each stratum.

[b] Adjusted for age; geographic site; age at first birth; number of live births; and level of education.

not found to be at increased risk [29, 33]. Although some studies suggest that this relationship is limited to post-menopausal women [32], we observe this association even when our population was restricted to pre-menopausal women (88.7% of total study population, data not shown). Among parous women, *teachers*, *librarians and counselors* were at significantly increased risk, while among nulliparous women there was no association. The increased risk estimates were essentially the same for all parous women when further stratified by early and late age at first birth (data not shown). In our study, risk was strongest among *teachers*, *librarians or counselors* who were employed in these occupations for less than five years; increased risk associated with short job duration may indicate that the occupational exposure is acting as a tumor promoter. To our knowledge, we are the first study to present risk estimates for short-term employment in this occupational group.

Elevated occupational breast cancer risk has often been attributed to reproductive characteristics. In the absence of confounding, parity-specific risk estimates would not be expected to differ from that of all women combined. This was the case for many occupations. Furthermore, risk may differ according to parity status. For all women combined, *natural scientists and mathematicians* were at a decreased risk of breast cancer, however among parous women, no risk was observed and among nulliparous women, the decreased risk became stronger and statistically significant. These stratified analyses do not provide support for the argument that increased risk associated with various occupations is due to uncontrolled confounding by reproductive status. It should be kept in mind that the majority of nulliparous women were still of childbearing age and represented only 24% of the study population, which resulted in small cell sizes. These findings need to be replicated in study populations with more nulliparous women.

Jobs held in electrically related industries such as electrical workers, electrical engineers, electrical technicians, telephone installers, and line workers may expose women to various levels of EMFs [34], which have been hypothesized to increase breast cancer risk [35]. Occupations in other industries that may also involve potentially elevated EMF exposures, such as telephone operators, data entry workers, and computer operators and programmers [34] as well as airline attendants [36]. A comprehensive review of the few existing studies of occupational EMF and breast cancer suggests that a relationship exists [37], although a recent case–control study of occupational EMF exposure found little evidence of such an association [5]. EMF exposure could occur among several occupations reported by women in our study, including *computer and peripheral equipment operators*; *communications equipment operators*; and *secretaries*, *stenographers and typists* as well as the industries *electronic and other electric equipment*; *electric*, *gas and sanitary services* and *air transportation*. Yet we found no substantial elevation in the risk estimates for having ever worked in many of these categories, except for the increased risk associated with working as a *computer and peripheral equipment operator* or in the *electric*, *gas and sanitary services* industry. Without a measure of the actual EMF exposure, it is difficult to draw any conclusions about the association between this occupational exposure and breast cancer, however our study provides only weak support for this hypothesis. Furthermore, potential exposure to EMF through electric blanket use was not associated with breast cancer risk in our study population [18].

As part of this study detailed information on the three longest held jobs as well as on established and potential breast cancer risk factors from a large population-based group of young women was collected and included in these analyses. Thus it is unlikely that these risk factors account for the observed occupation-breast cancer associations although residual confounding remains a possibility. The detailed information collected on job title, usual activities or duties performed, and what the company made or did allowed an industrial hygienist to uniformly code both occupation and industry according to the 1987 SIC and 1980 SOC codes, which group occupations according to the nature of the work performed [20, 21]. To conduct meaningful statistical analyses, initially assigned SIC and SOC codes were collapsed to create as distinct categories as possible with respect to potential occupational exposures while maintaining sufficient cell sizes.

The detailed job history enabled us to examine breast cancer risk not only in relation to ever having worked in a particular occupation or industry but also in relation to duration of employment and the latency (*i.e.*, the time between starting a job and the reference date). This is contrast to several previous studies that only examined breast cancer risk in relation to the longest held or usual job [26, 29, 32]. The use of longest held job could bias associations toward the null since the reference group may include women employed in the occupation for a shorter period. Our ability to examine occupation categorized by job duration allowed us to reduce the likelihood of misclassification since our reference group was restricted to women who did not report the job as one of their three longest held.

Each job reported by a participant was represented in the dataset by a SIC/SOC pair. Due to the number of jobs reported, a large number of occupation/industry

combinations resulted and it was not practical to include both occupation and industry together in the analytic models. Since each occupation or industry category was examined separately, it is possible that estimates of effect were diluted because women included in the unexposed group may have actually had exposures from jobs they held in other occupational or industrial categories similar to the women in an exposed group. For example, 78.3% of the jobs assigned to the occupational category of *teacher*, *librarian or counselor* were also assigned to the industrial category of *educational services*. Yet, of the jobs assigned to *educational services*, only 57.8% were also assigned the occupation code for *teacher, librarian or counselor*. The association between working in the *educational services* industry and breast cancer risk was essentially null, which may be because several low-risk occupations, such as *executive, administrative and managerial* and *secretaries*, *stenographers and typists*, also fell under this industrial category.

Several limitations traditionally associated with occupational epidemiologic studies should be considered with respect to our results. For those occupational and industrial categories for which we observed reduced or no risk of breast cancer, we cannot rule out the possibility that less breast cancer may be observed in a particular occupation or industry because women may self-select themselves out of the jobs that involve carcinogenic exposures. Although a wide range of occupations and industries were reported in this study, the number of study participants who worked in any one job or industry tended to be small, limiting our ability to clearly identify relationships between a particular occupation (or industry) and breast cancer risk. In addition, only information on the three longest held jobs was ascertained, so short-term jobs that could have acute but conceivably, adverse occupational exposures were not necessarily accounted for in these analyses. Statistically significant findings could be due to the large number of comparisons that were conducted. It should be noted that none of the study participants reported housewife as one of their three longest held jobs, most likely due to the design of the questionnaire's occupational history section. It is possible that the 24 women who reported that they were never employed for six months or longer were solely housewives. Since we do not have this information, we could not conduct analyses that excluded housewives as has commonly been done in studies of occupation and breast cancer risk [29]. Exclusion of the women who never worked did not alter the results. The use of a single reference group of 'occupationally unexposed' women would ensure comparability of ORs and avoid possible residual confounding. However, in this population, the use of a single reference group was not possible given the small number of women who reported never having worked more than 6 months.

Occupational exposures in relation to cancer have, until recently, been primarily studied among men [38]. To our knowledge, we are among the first population-based case–control studies to examine occupational history and breast cancer risk in women 20–44 years of age, with the ability to take a wide array of breast cancer risk factors into consideration. Case–control studies such as ours are essential for identifying potential occupations and industries that put women at increased breast cancer risk, but these studies cannot pinpoint the particular exposures underlying the association. Job exposure matrices have been used in some studies to better elucidate the occupational exposure-breast cancer risk relationship [39, 40], and future case–control research efforts should consider employing advanced exposure assessment techniques [41]. To better identify job-related breast cancer risk factors, however, occupational cohort studies that collect detailed information on exposures received at work in addition to comprehensive information on established and putative breast cancer risk factors need to be undertaken.

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